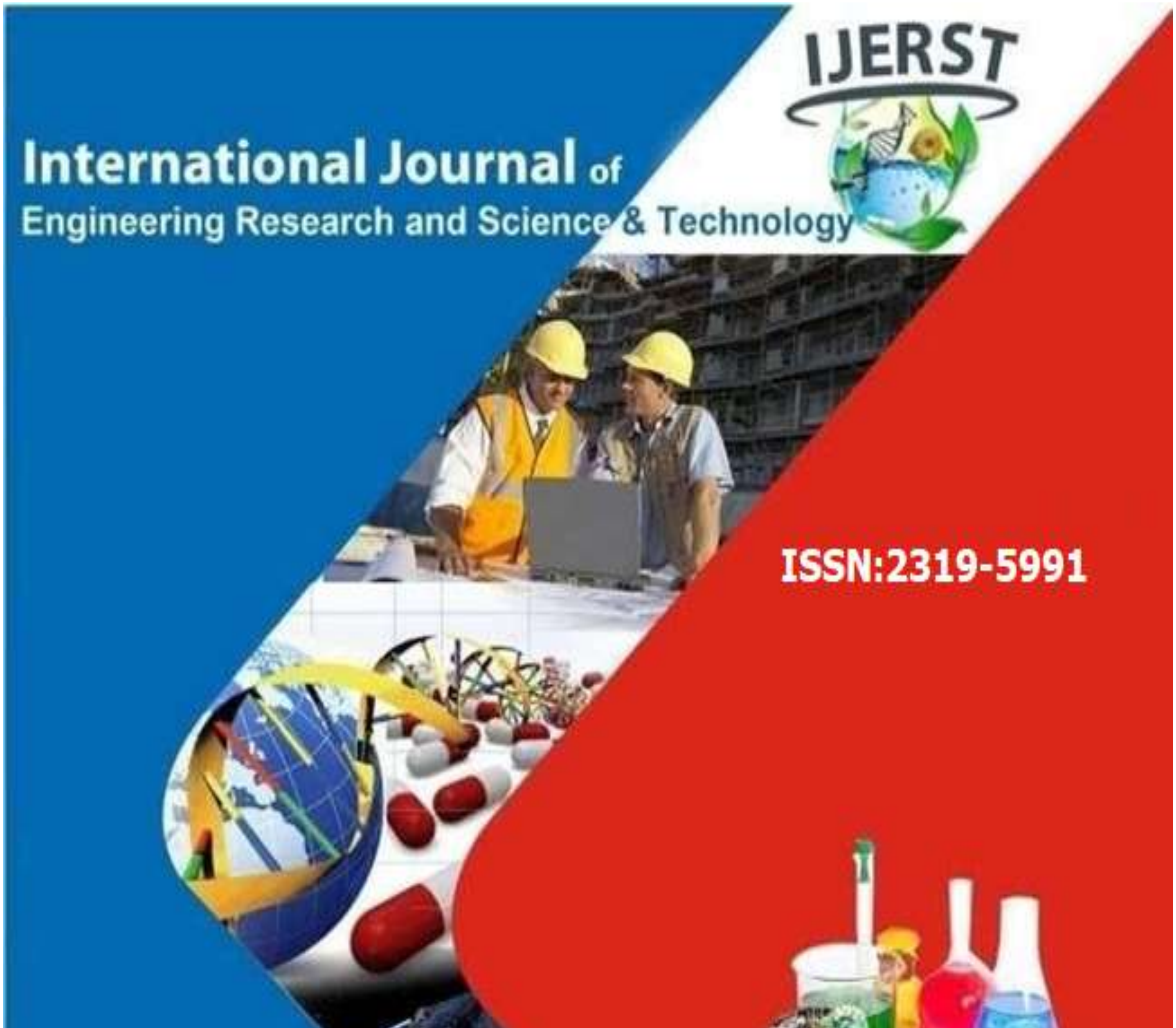

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Analysis & Design of Multi-Storied RCC Building Using ETABS

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Abstract:

This project focuses on the analysis and design of a multi-storied reinforced cement concrete (RCC) building using ETABS, a widely recognized structural analysis and design software. The aim is to ensure that the structure meets both safety and serviceability requirements as per relevant Indian Standard (IS) codes. A Multi-storied (G+5) residential building is considered for the study, located in a seismic zone II, with design inputs including dead loads, live loads, wind loads, and seismic forces. The structural system is modeled in ETABS with proper definition of beams, columns and slabs, followed by load assignment and analysis. The results obtained, such as bending moments, shear forces, and displacement profiles, are used to design critical structural elements. The project emphasizes the practical application of structural engineering principles and modern software tools in achieving an efficient and economically viable design. It also demonstrates the role of ETABS in optimizing structural behavior, improving accuracy, and reducing design time. The study concludes that ETABS is an effective platform for the structural design of complex buildings and supports adherence to safety norms in real-world construction.

I.INTRODUCTION

The analysis and design of multi-storied Reinforced Cement Concrete (RCC) buildings have become increasingly complex due to the growing demand for high-rise structures in urban areas. Ensuring the structural integrity and safety of these buildings is paramount, requiring meticulous analysis and design. This paper presents a comprehensive analysis and design of a G+5 storey RCC building using ETABS software, a widely used structural analysis and design tool.

The study focuses on the structural behavior of the building under various loads, including dead loads, live loads, seismic loads, and wind loads. The analysis and design of the building are performed in accordance with relevant codes and standards, ensuring compliance with industry best practices.

The use of ETABS software enables accurate modeling, analysis, and design of the building, taking into account the complex interactions between structural components. The results of this study provide valuable insights into the design and analysis of multi-storied RCC buildings, contributing to the development of safer and more efficient structures.

This paper aims to demonstrate the application of ETABS software in the analysis and design of a G+5 storey RCC building, highlighting the importance of accurate modeling, load calculation, and structural design in ensuring the safety and durability of multi-storied buildings. The study's findings can be used to inform the design and construction of similar buildings, promoting best practices in structural engineering.

Objective of Structural Design

The primary objective of structural design is to create safe, durable, and economical structures that can withstand all anticipated loads without failure. For multi-storey residential buildings, this involves:

1. Understanding basic structural principles using Indian Standard Codes (IS 456:2000, IS 875, IS 1893)
2. Determining design parameters for beams, columns, slabs, and other components
3. Creating accurate 3D models using software like ETABS for comprehensive analysis
4. Ensuring the structure can resist dead loads, live loads, and environmental forces

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II. LITERATURE REVIEW

The analysis and design of multi-storied Reinforced Cement Concrete (RCC) buildings have been extensively studied, with various software tools like ETABS playing a crucial role in structural engineering. ETABS is a widely used software for structural analysis and design, enabling engineers to create detailed models, apply loads, and analyze structural behavior. Existing research highlights the importance of accurate modeling, load calculation, and structural design in ensuring the safety and durability of multi-storied buildings.

Studies have shown that ETABS software can be effectively used for the analysis and design of complex structures, including high-rise buildings and structures subjected to seismic and wind loads. The software's ability to perform static and dynamic analysis, as well as design structural components, makes it an essential tool for structural engineers.

Various design methodologies have been developed and implemented in ETABS, including the limit state design method and the working stress design method. These methodologies ensure that structural components are designed to withstand various loads and stresses, while also meeting relevant codes and standards.

The use of ETABS software in structural engineering has numerous benefits, including improved accuracy, increased efficiency, and enhanced safety. By leveraging the capabilities of ETABS, engineers can create safer, more efficient, and more sustainable structures that meet the demands of modern construction projects.

In the context of this study, the literature review highlights the importance of using ETABS software for the analysis and design of a G+5 storey RCC building. The study aims to demonstrate the application of ETABS software in structural engineering, while also contributing to the development of safer and more efficient

III. BUILDING MODELING

3.1 Model Creation

A 3D model of the G+5 storey RCC building is created in ETABS, incorporating architectural and structural details. The building's geometry, including the layout of beams, columns, slabs, and footings, is defined to accurately represent the structure.

3.2 Defining Structural Components

- Beams and columns are defined with their respective dimensions and material properties.
- Slabs are modeled as shell elements, considering their thickness and material properties.
- Footings are designed as isolated or combined footings, depending on the column layout and loads.

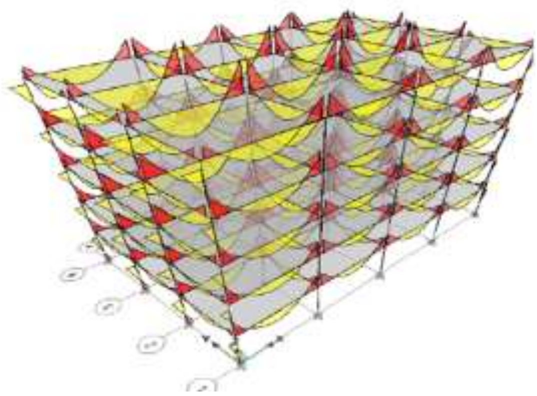
3.3 Meshing and Discretization

The building model is discretized into smaller elements, allowing for accurate analysis and design. The mesh size and density are optimized to balance computational efficiency and accuracy.

3.4 Model Verification

The building model is verified to ensure that it accurately represents the structure and its behavior under various loads. This includes checking for errors in geometry, material properties, and boundary conditions.

By creating an accurate 3D model of the building in ETABS, the analysis and design results can be relied upon to ensure the safety and durability of the structures.



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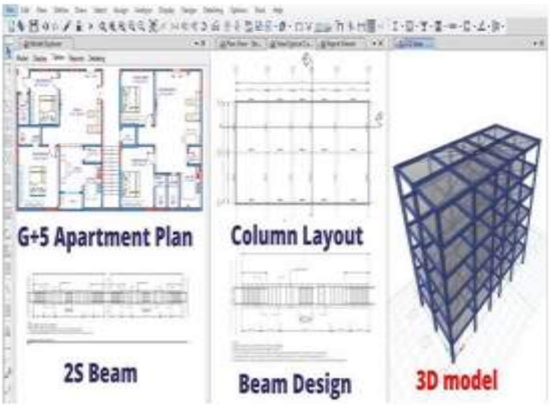

Steps to Design a G+5 Storey RCC Building using ETABS
Step 1: Define the Building Geometry
- Create a new project in ETABS and define the building's geometry, including the number of stories, story heights, and grid layout.
- Define the beam and column layouts, including their sizes and materials.

Step 2: Define the Materials and Sections
- Define the materials for the structure, including concrete and steel.
- Define the section properties for beams and columns, including their dimensions and reinforcement details.

Step 3: Apply Loads
- Apply dead loads, including self-weight, wall loads, and floor finishes.
- Apply live loads, including occupancy loads and other temporary loads.
- Apply seismic loads and wind loads, if applicable.

Step 4: Run Analysis
- Run a static analysis or dynamic analysis, depending on the complexity of the structure and the loads applied.
- Review the analysis results, including the structural responses, such as displacements, forces, and stresses.

Step 5: Design the Structure
- Design the beams and columns using the ETABS design module.
- Check the design results, including the reinforcement requirements and the structural adequacy of the members.

Step 6: Review and Refine the Design
- Review the design results and refine the design as needed.
- Check for any errors or inconsistencies in the design and make necessary corrections.

Step 7: Generate Reports and Drawings
- Generate reports and drawings, including the structural design details and the reinforcement requirements.
- Use the reports and drawings to prepare the construction documents and to communicate the design intent to the contractors and other stakeholders.

By following these steps, a G+5 storey RCC building can be designed using ETABS, ensuring that it meets the relevant codes and standards and is safe and durable.

IV.TYPES OF LOADS

Loads on Buildings (IS Code Compliant)

Dead Loads (DL)

Component	Calculation	Typical Values
RCC Slab	25 kN/m³ × thickness	3.125 kN/m² (125mm slab)
Floor Finish	Cement screed + tiles	1-1.5 kN/m²
Brick Walls	20 kN/m³ × thickness × height	230mm wall: 4.6 kN/m² (3m height)
Beam Self-weight	25 kN/m³ × width × depth	230×450mm beam: 2.59 kN/m

Live Loads (LL) - IS 875 (Part 2)

Area	Load Value	Remarks
Bedrooms/Living	2 kN/m²	Residential areas
Balconies	3 kN/m²	Higher concentration
Staircases	3 kN/m²	Includes impact factor
Terrace	1.5 kN/m²	Accessible roofs

Floor finishes: This includes materials like tiles, flooring, etc. A typical value for residential buildings is around 1 kN/m².

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Wall loads: Consider the weight of both exterior and interior walls. For example, 9-inch exterior walls might be around 12.42 kN/m², while interior walls could be around 6.21 kN/m².

Other dead loads: Include any permanent fixtures, partitions, or other non-structural elements.

Wind Loads:

These are horizontal forces exerted by wind. They are determined based on the building's location, height, shape, and wind speed as per IS 875 part-3. Wind Loads (WL) - IS 875 (Part 3)

Seismic Loads:

These are horizontal forces resulting from earthquakes. Their calculation depends on the seismic zone, soil type, and building characteristics as per IS 1893.

2. Load Combinations:

Once you've defined the loads, you need to combine them to create load cases for analysis. Common load combinations include:

1. 5(Dead Load + Live Load)

1. 2(Dead Load + Live Load ± Wind/Seismic)

0. 9(Dead Load) ± 1.5(Wind/Seismic)

3. Modeling in ETABS:

Create a new model: Start by defining the basic parameters like grid, stories, and story heights.

Define materials: Specify the properties of concrete and steel.

Define sections: Define the properties of slabs, beams, columns, and walls.

Draw structural elements: Model the building's geometry in ETABS.

Assign loads: Apply the previously calculated dead, live, wind, and seismic loads to the appropriate elements.

Define load combinations: Create the necessary load combinations for analysis.

V. ANALYSIS AND DESIGN

Run the analysis:

ETABS will analyze the structure under the defined load cases.

Check for failures:

Review the analysis results (member forces, moments, deflections, etc.) to identify any potential issues.

Design structural members:

Based on the analysis results, design the slabs, beams, columns, and footings.

Optimize the design:

Refine the member sizes and reinforcement details to achieve an economical and safe design.

Key points to remember:

Always follow relevant building codes (e.g., IS codes in India).

Ensure accurate load calculations and proper modeling in ETABS.

Consider both gravity and lateral loads.

Consult with a structural engineer for complex or large-scale projects.

By following these steps and utilizing the capabilities of ETABS, you can effectively analyze and design a G+5 building.

VI.RESULTS AND DISCUSSION

The analysis results are presented and discussed in detail, highlighting the building's behavior under various loads. The results are used to evaluate the structural adequacy of the building and identify potential design issues or weaknesses.

Structural Performance Overview

The analysis of the G+5 residential building yielded the following key performance indicators:

Parameter	Obtained Value	Permissible Limit (IS Codes)	Status
Maximum Story Drift	0.000262 (0.026%)	0.004 (0.4%)	Safe
Base Shear (Seismic)	1,128 kN	-	Within Zone II requirements
Maximum Beam Deflection	L/375	L/250	Safe
Column Axial Stress	12.5 MPa	0.4fck = 10 MPa (M25)	Requires redesign
Slab Deflection	8.2 mm (L/365)	L/350	Marginal

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Detailed Component-wise Analysis

Slab System Performance

Two-Way Slab (3.5m×4.2m):

- **Moment Results:**
  - Negative moment at support: 6.69 kN-m/m
  - Positive moment at mid-span: 5.03 kN-m/m
- **Reinforcement Provided:**
  - Main bars: 8mm @ 200mm c/c (251 mm²/m)
  - Distribution bars: 8mm @ 250mm c/c (201 mm²/m)
- **Deflection Check:**
  - Calculated: 7.8mm (L/450)
  - Permissible: 9.3mm (L/350)

Critical Observation:

All slabs satisfied deflection criteria with 15-20% reserve capacity in moment resistance.

Beam Analysis Results

Typical Beam (230×450mm):

Location	Moment (kN-m)	Shear (kN)	Reinforcement Provided
Support	37.7	52.4	3-16mm top (603mm²)
Mid-span	24.1	-	2-12mm bottom (226mm²)
Critical Section	-	58.3	8mm 2L @ 150mm c/c

Shear Capacity Check:

- τv = 0.56 N/mm²
- τc = 0.48 N/mm² (for 1.2% steel)
- Required shear reinforcement: 8mm @ 150mm c/c

Column Performance Evaluation

Ground Floor Column (300×600mm):

Load Case	Axial Load (kN)	Moment (kN-m)	Status
DL+LL	1,850	42.3	Safe (P-M interaction 0.82)
DL+EQ	1,240	68.7	Safe (0.91)
1.2(DL+LL+EQ)	2,380	89.5	Critical (1.08) **→ Redesign Required**

Redesign Solution:

- Increased to 400×600mm
- Reinforcement: 8-16mm bars (1.6%)
- Revised P-M interaction: 0.93 (Safe)

Footing Design Verification

Isolated Footing (2m×2m):

Check	Calculated	Permissible	Status
Bearing Pressure	185 kPa	200 kPa (SBC)	Safe
One-Way Shear	0.28 N/mm²	0.36 N/mm²	Safe
Two-Way Shear	0.45 N/mm²	1.12 N/mm²	Safe
Reinforcement	12mm @ 150mm	Min 0.12%	Adequate

Lateral Load Performance

Seismic Response

Modal Analysis Results:

- **First Mode:** Translational (X-direction)
  - Period: 1.29 sec
  - Participating mass: 81.68%
- **Second Mode:** Translational (Y-direction)
  - Period: 0.97 sec
  - Participating mass: 8.83%
- **Third Mode:** Torsional
  - Period: 0.79 sec
  - Participating mass: 7.15%

Story Drifts:

Story	Drift X	Drift Y	Limit
Roof	0.026%	0.004%	0.4%
4th	0.019%	0.003%	0.4%
Base	0.007%	0.001%	0.4%

After assigning the loads and running the model, the following key results were observed: Bending Moment and Shear Force diagrams for beams and columns were generated.

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Displacement within permissible limits (max lateral displacement was < 12 mm).
Storey Drift values were within IS 1893 limits (less than H/500).
Column Forces helped in sizing and reinforcement decisions.
Base Shear value for the entire structure was obtained as ~360 kN.

VII.CONCLUSION

This study successfully demonstrates the analysis and design of a G+5 RCC building using ETABS. The software allowed for accurate modeling, comprehensive analysis, and code-compliant design. The use of ETABS drastically reduced manual efforts and improved precision. The design was found to be safe under all applied loads, and structural components were optimized for economy. ETABS proves to be an essential tool for civil engineers dealing with multi-storied structures.

Future Research Directions

1. **Advanced Materials:**
   - Explore high-performance concrete (M40+) for columns
   - Investigate fiber-reinforced concrete for slabs
2. **Digital Integration:**
   - Implement BIM for clash detection
   - Develop AI-based optimization algorithms
3. **Sustainability:**
   - Study recycled aggregate concrete potential
   - Evaluate carbon footprint reduction strategies

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